PROCEEDINGS

SIXTH INTERNATIONAL WORKSHOP NANOCARBON PHOTONICS AND OPTOELECTRONICS

19-24 March 2017, Krasnaya Polyana, Sochi, Russia

MOSCOW, RUSSIA 2017

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Proceedings

Sixth International Workshop Nanocarbon Photonics and Optoelectroni

Krasnaya Polyana, Sochi, Russia

Edited by Timofei Eremin

Moscow, Russia
2017

Influence of temperature on optical limiting of detonation nanodiamonds suspension in engine oil

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Optical limiting (OL) is a nonlinear optical phenomenon at which the transmittance of the medium under study nonlinearly decreases, with increasing the incident radiation power density [1]. The OL in various carbon nanomaterials suspensions has been investigated intensively [2,3], since these materials are widely recognized as very promising for the OL applications [4]. It was shown that the aqueous detonation nanodiamonds (DNDs) suspensions are well suited for developing and creating an optical limiter capable to work in a wide spectral range [5]. However such an optical limiter could not perform both at temperatures close to 100 °C and below 0 °C, since the state of aggregate of host liquid changes. One of the ways to improve it is to use a non-freezing host liquid, e.g. engine oil. Our preliminary experiments have shown the DNDs suspensions in engine oil to be super stable and they have not developed sediment after seven years. Moreover, DNDs suspensions with nanoparticles clusters average size (D_{aver}) 110 and 320 nm in engine oil are more stable than that in water, while the OL efficiency in these suspensions increases with increasing the D_{aver} [3]. It makes study of the OL of DNDs suspensions in engine oil relevant in terms of creation of optical limiters capable to work in a wide temperature range. In this paper we study the influence of temperature on the OL properties of the DNDs suspension in engine oil and, since the mechanisms of the OL in aqueous and oil DNDs suspensions could be different, we also discover the mechanism of the OL in oil suspensions of DNDs.

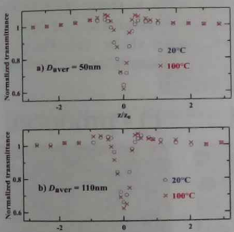

Fig. The normalized transmittances of the (a) 50 and (b) 110 nm DNDs suspensions in engine oil as functions of z/z_0 measured at different temperatures. The input pulse energy was 88 μJ, the diffraction length of the beam (z_0) was 6.9 mm.

In our experiments we used DNDs which were obtained by a known technology [6]. The 1 wt.% suspensions of DNDs were obtained in engine oil for the experiments. For preparation of engine oil suspensions of DNDs, the particles with an average size of clusters D_{aver}=50 nm and D_{aver}=110 nm in hydrosols were used. OL study was carried out by z-scan technique; 532 nm radiation of YAG:Nd^{3+}-laser with passive Q-switching was used as an excitation source [7]. Laser pulse duration was 13.6 ns. In order to heat the suspension, the cell was placed into the specially designed thermostat with two windows for laser beam, able to heat the whole sample up to 100°C and keep preset temperature constant.

In Fig. the results of z-scan study of 50 and 110 nm DNDs suspensions obtained at 532 nm at oil temperatures of 20°C and 100°C are presented. The z-scan data measured at temperatures of 20°C and 100°C are shown to be almost identical. The same results were obtained at middle temperature points for both suspensions. This indicates that increasing the engine oil temperature up to 100°C is not accompanied with the OL threshold changing. Therefore, independence of the OL performance on the temperature makes it possible to use the DNDs suspension in engine oil as optical limiter at the temperature range of 20-100°C. In addition, this fact could be used to discover the nature of nonlinear scattering in the oil DNDs suspension.

Acknowledgement

This work was financially supported by RFBR (project No 16-38-00553).

References

[1] K. Mansour, M.J. Soileau, E.V. Van Stryland, J. Opt. Soc. Am. B., **9**, 7, 1992.
[2] I.M. Belousova, D. A. Videnichev, I. M. Kislyakov, T. K. Krisko, N. N. Rozhkova, S. S. Rozhkov, Opt. Mater. Express, **5**, 1, 2015.
[3] V. V. Vanyukov, T. N. Mogileva, G. M. Mikheev, A. P. Puzyr, V. S. Bondar, Y. P. Svirko, Appl. Opt., **52**, 18, 2013.
[4] J. Wang, Y. Chen, R. Li, H. Dong, L. Zhang, M. Lotya, J. N. Coleman and W. J. Blau. *Nonlinear Optical Properties of Graphene and Carbon Nanotube Composites* (Carbon Nanotubes - Synthesis, Characterization, Applications, InTech, 2011).
[5] V. V. Vanyukov, G. M. Mikheev, T. N. Mogileva, A. P. Puzyr, V. S. Bondar, Y. P. Svirko, Appl. Opt., **54**, 11, 2015.
[6] V.S. Bondar, A.P. Puzyr, Phys. Solid State, **46**, 4, 2004.
[7] G. M. Mikheev, R. Yu. Krivenkov, K. G. Mikheev, A. V. Okotrub, T. N. Mogileva, Quantum Electron., **46**, 8, 2016.